

# Toward the Micro-X TES Rocket



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# The Micro-X Collaboration

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- (3) National Institutes of Standards and Technology
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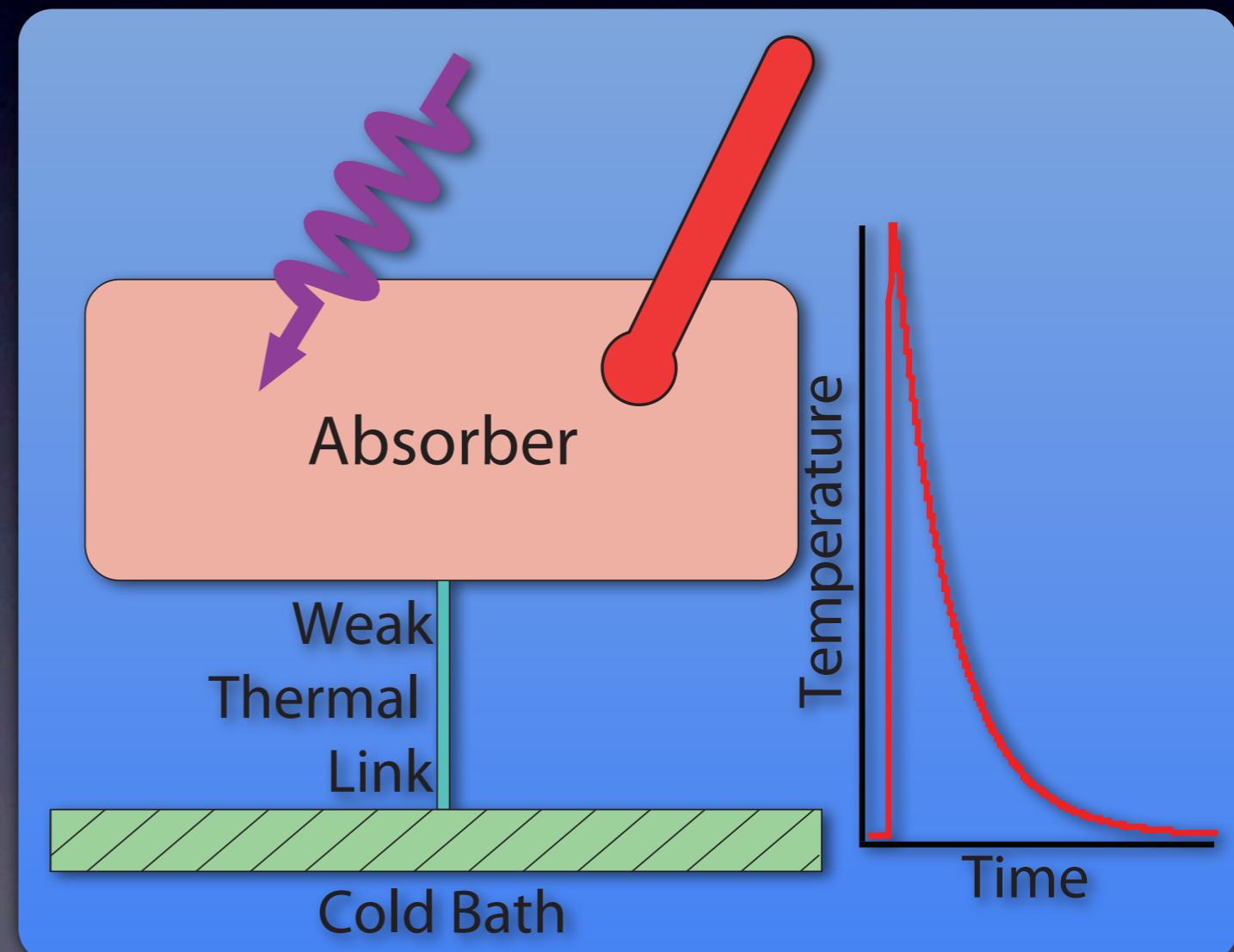




# Microcalorimeters 101

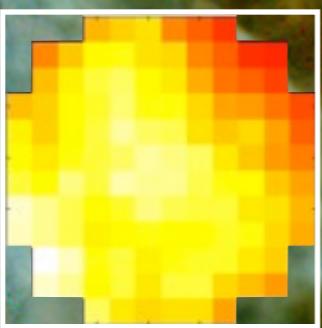
- Absorber and thermometer are connected to a thermal bath through a weak thermal link.
- Theoretical resolution is a function of T and  $E_{\max}$
- Need cryogenic temperatures to reach target resolution!

$$\Delta E_{\text{FWHM}} \simeq 2.36 \sqrt{4kT E_{\max}}$$





# Micro-X Science



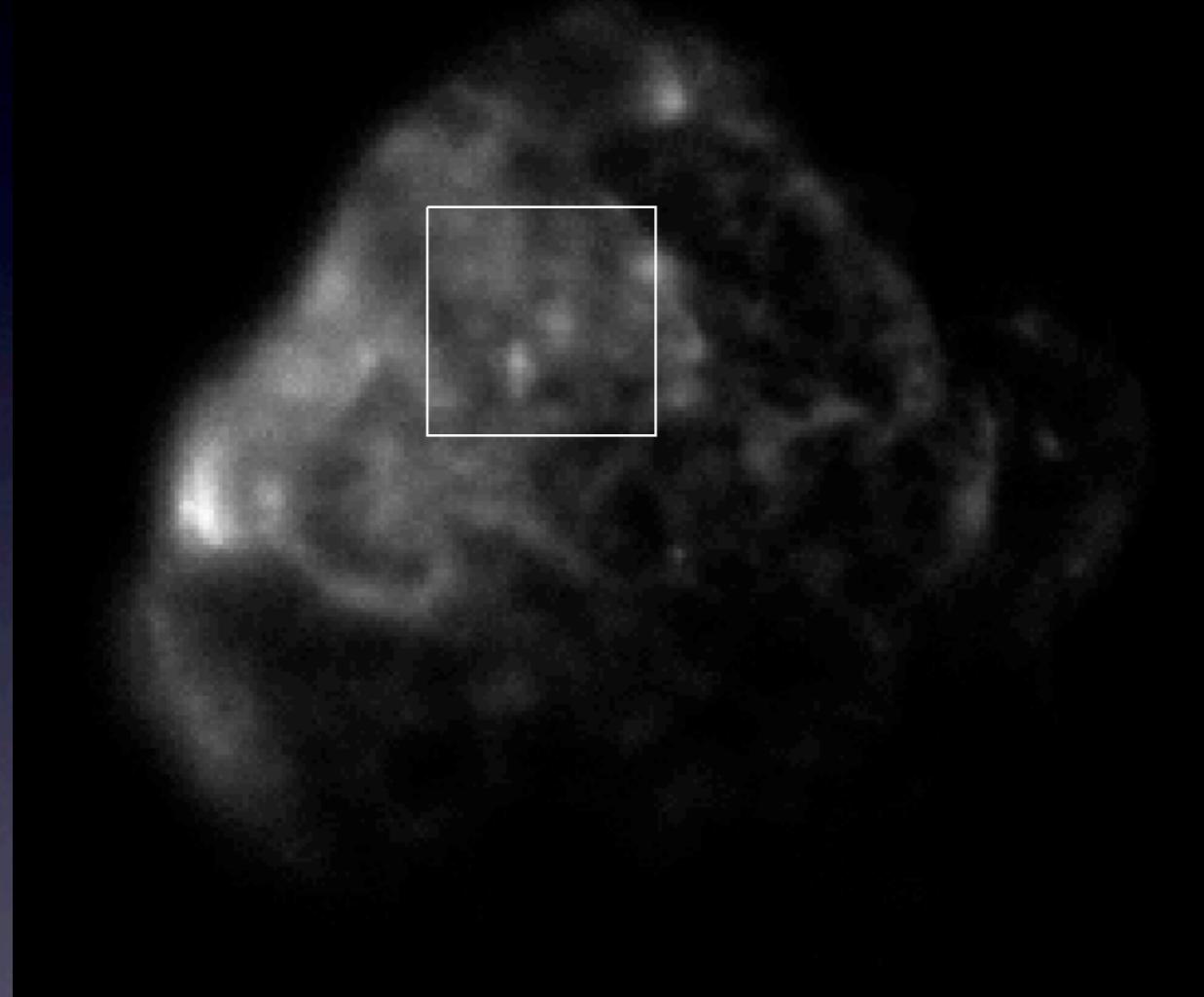
Katsuda et al. 2010

- Puppis A: Middle Aged (4000 years old) Oxygen-rich remnant
- Complex interactions between ejecta and interstellar environment
- High surface brightness, 1 keV temperature

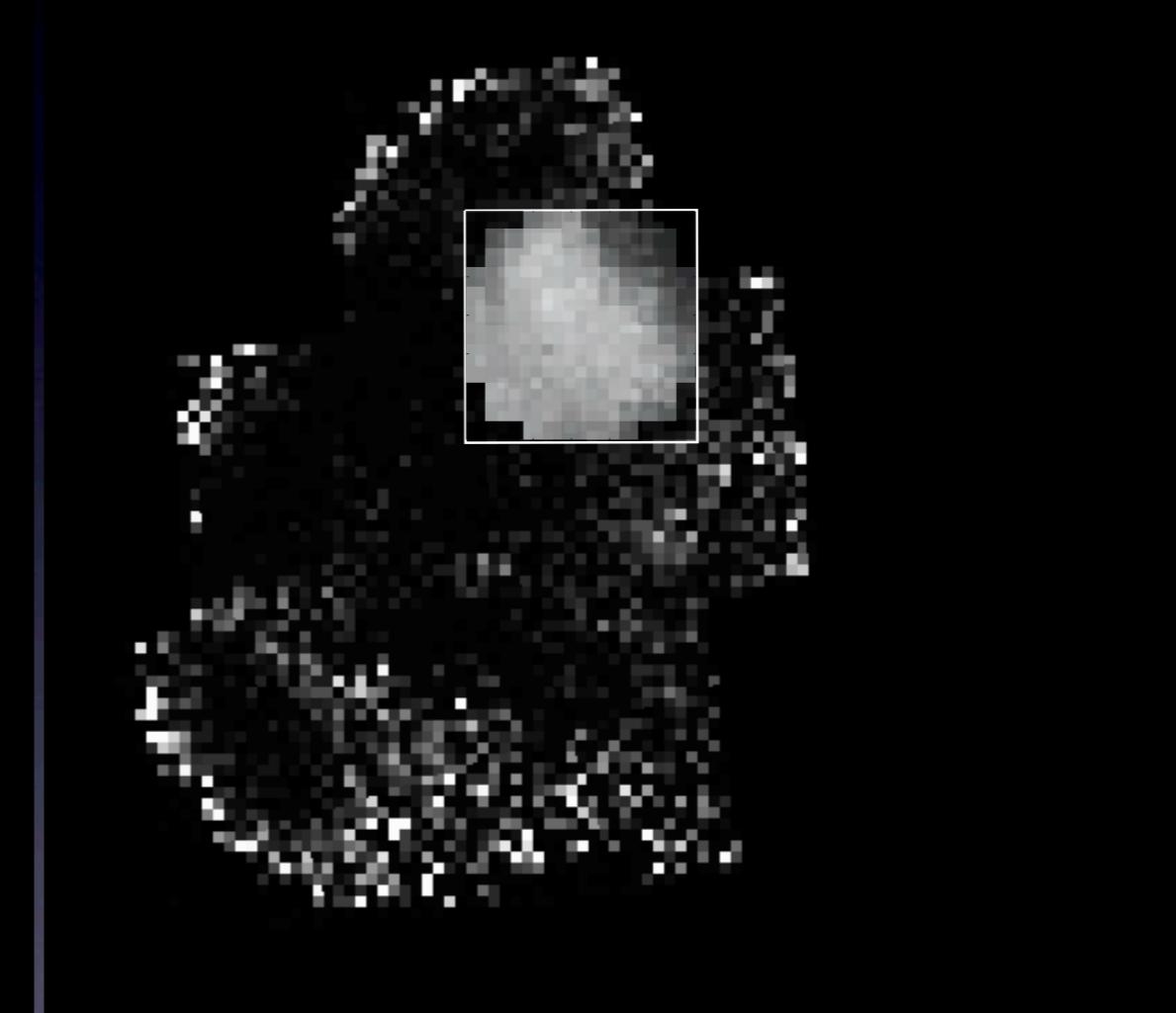


# Si Knot: Mostly Ejecta!

ROSAT 0.5-2.2 keV



Suzaku Si EQW

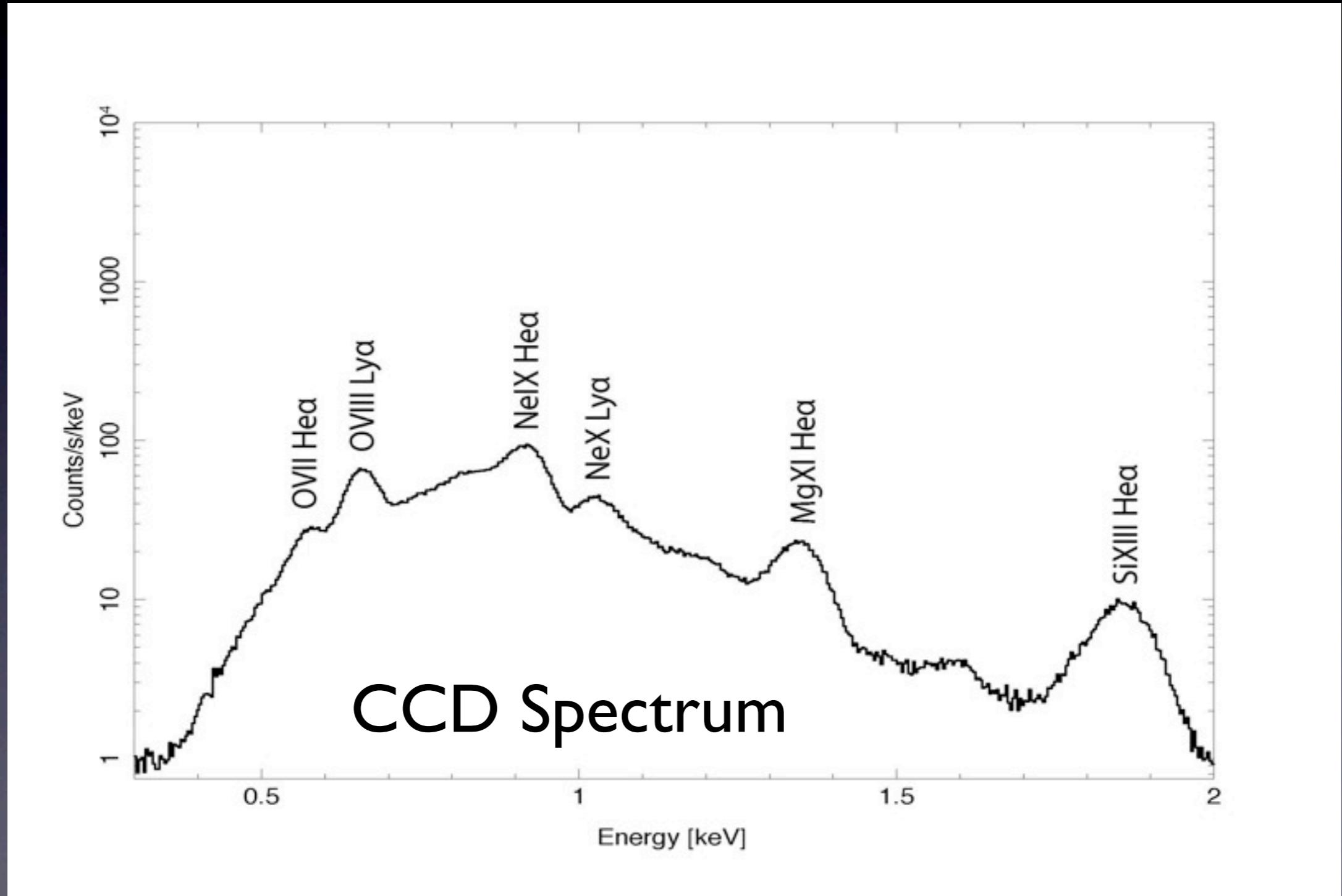


U. Hwang et al. 2008

S. Katsuda et al. 2008



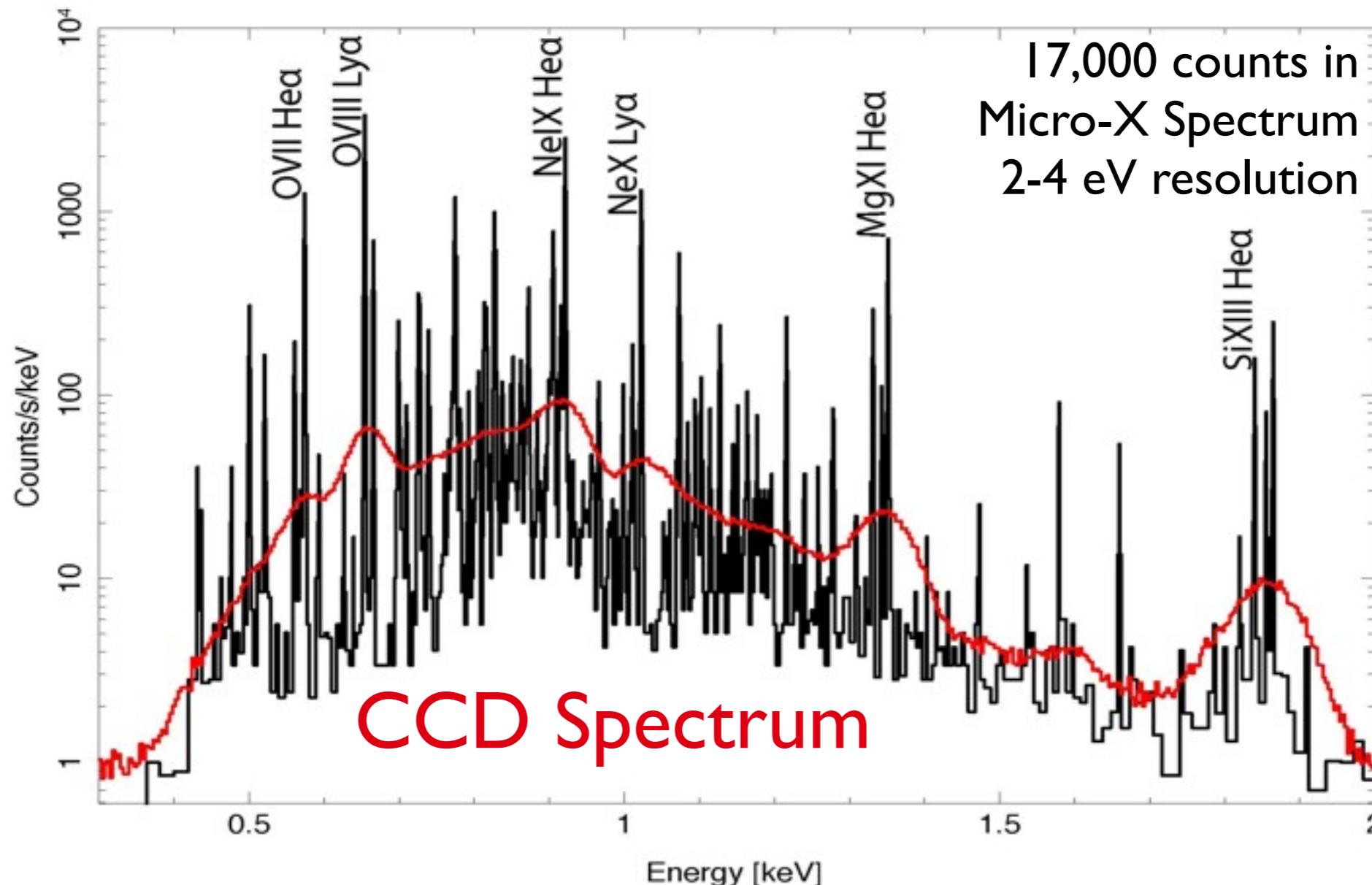
# The Power of High-Resolution Spectroscopy with Micro-X





# The Power of High-Resolution Spectroscopy with Micro-X

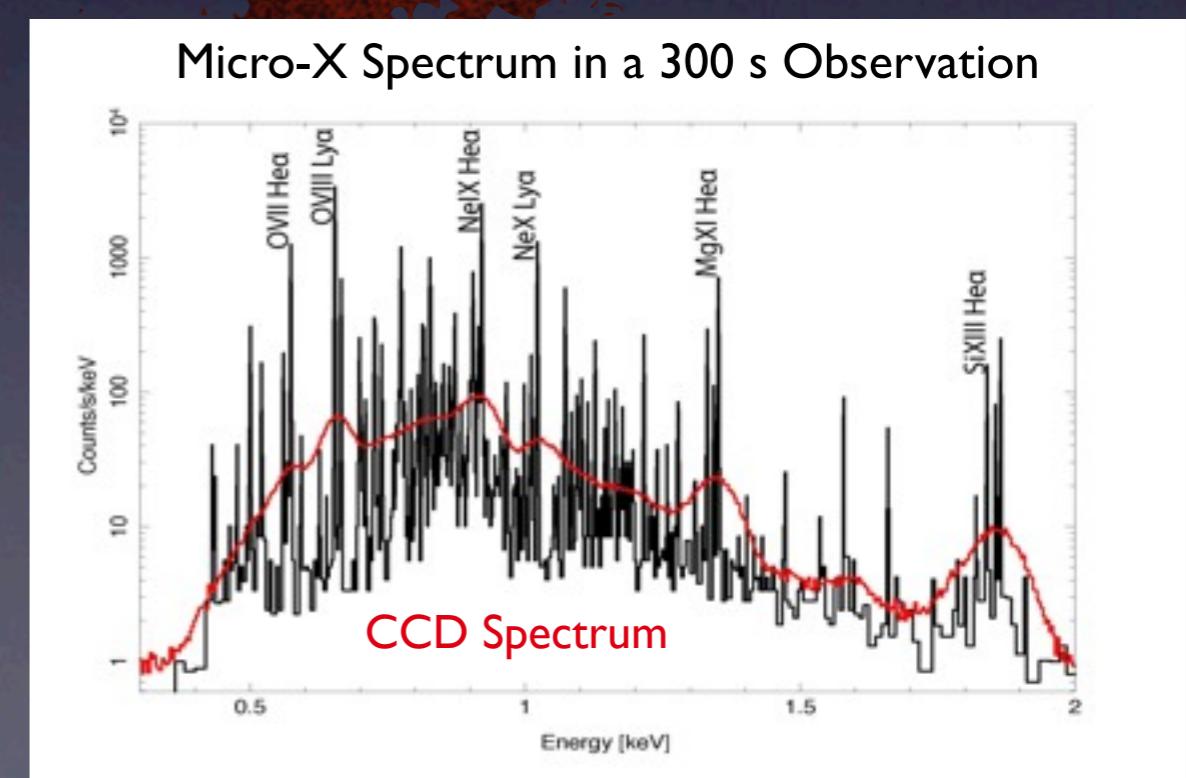
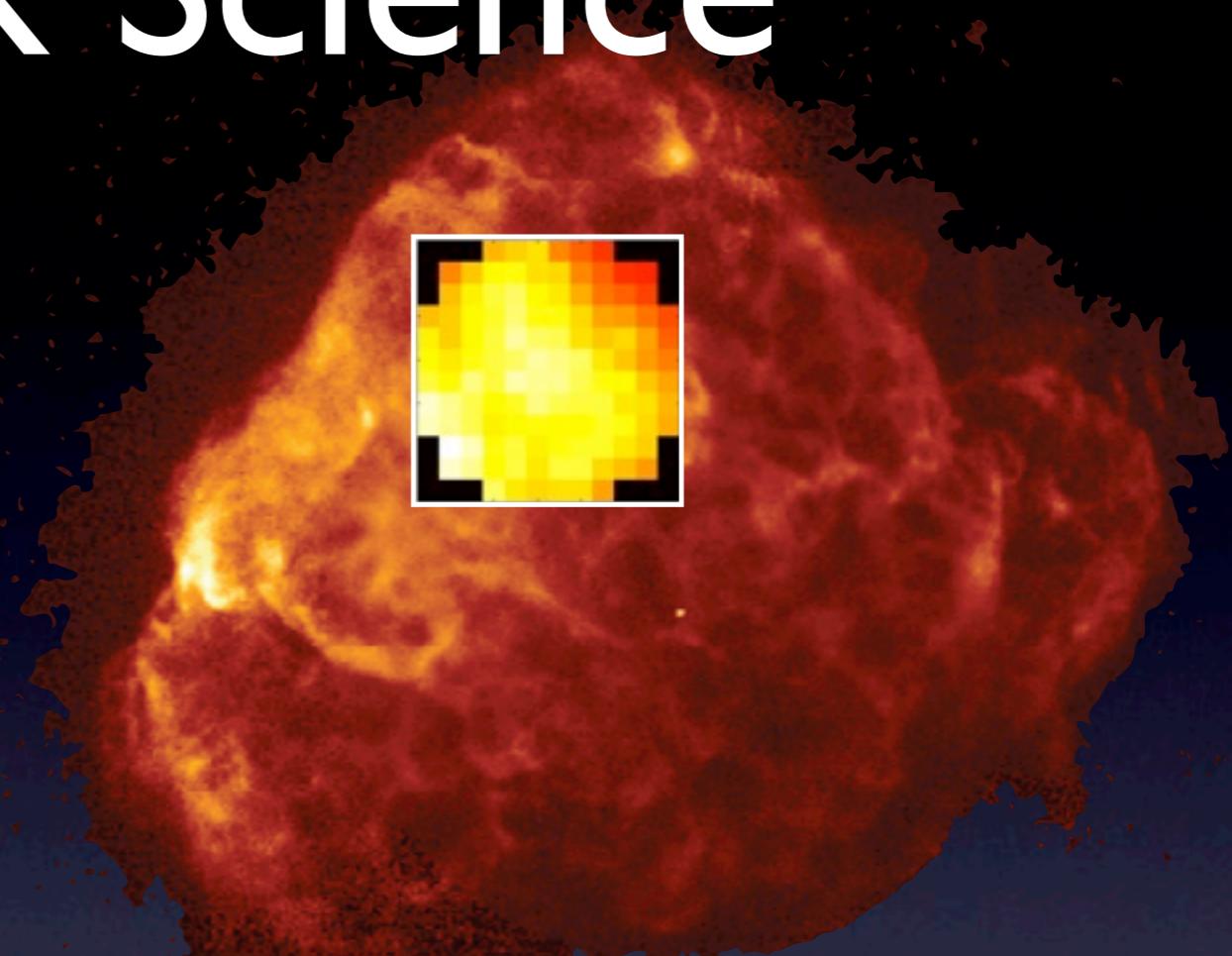
## Micro-X Spectrum in a 300 s Observation





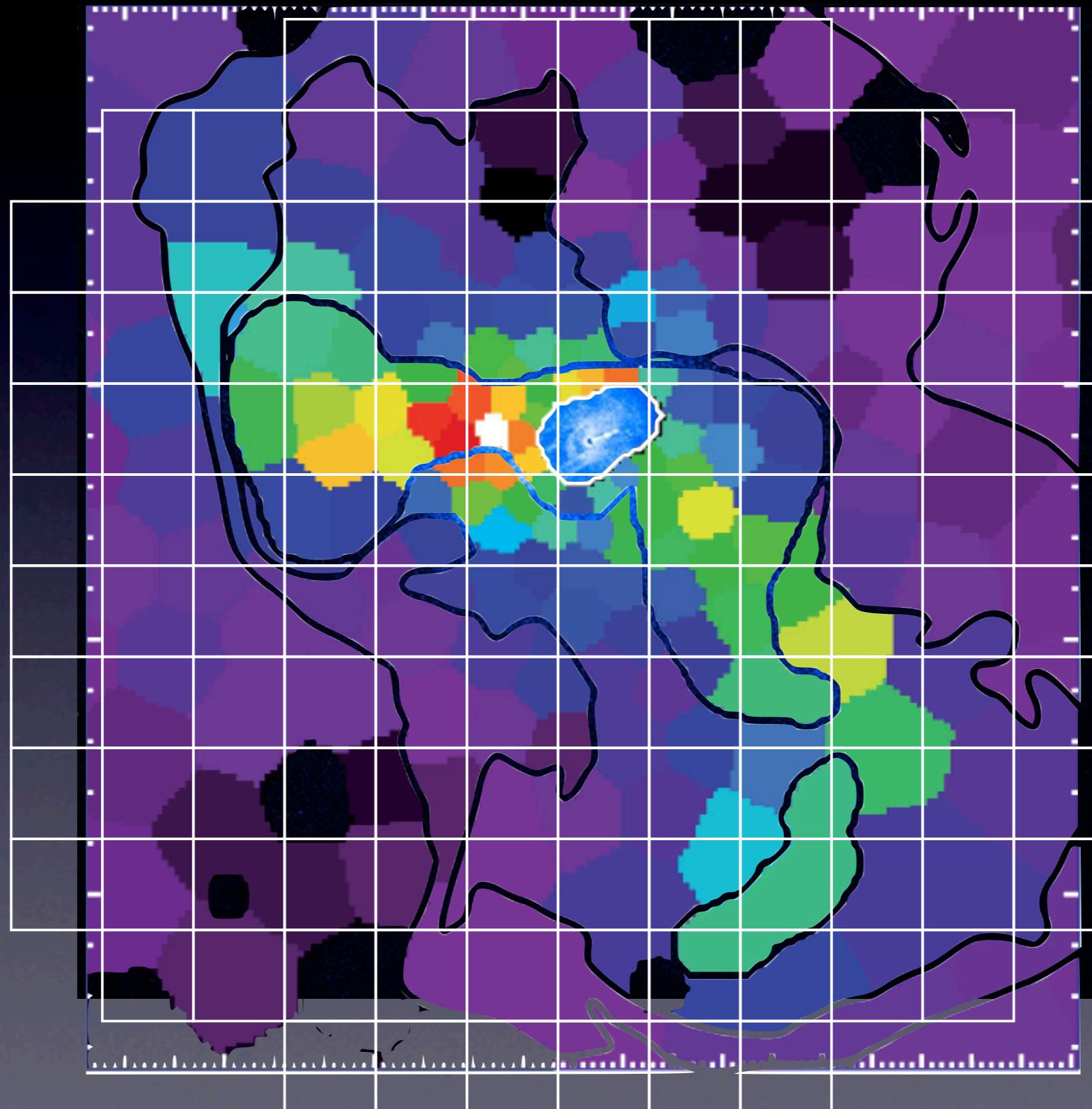
# Micro-X Science

- Search for velocity shifts in the various emission lines and measure the line structures to obtain information about the dynamics of the various ejecta elements.
- Perform plasma diagnostics for the various emission lines of individual elements to ascertain how similar or different the thermodynamic states of the various elements are.
- Refine estimates of element abundances in the ejecta.





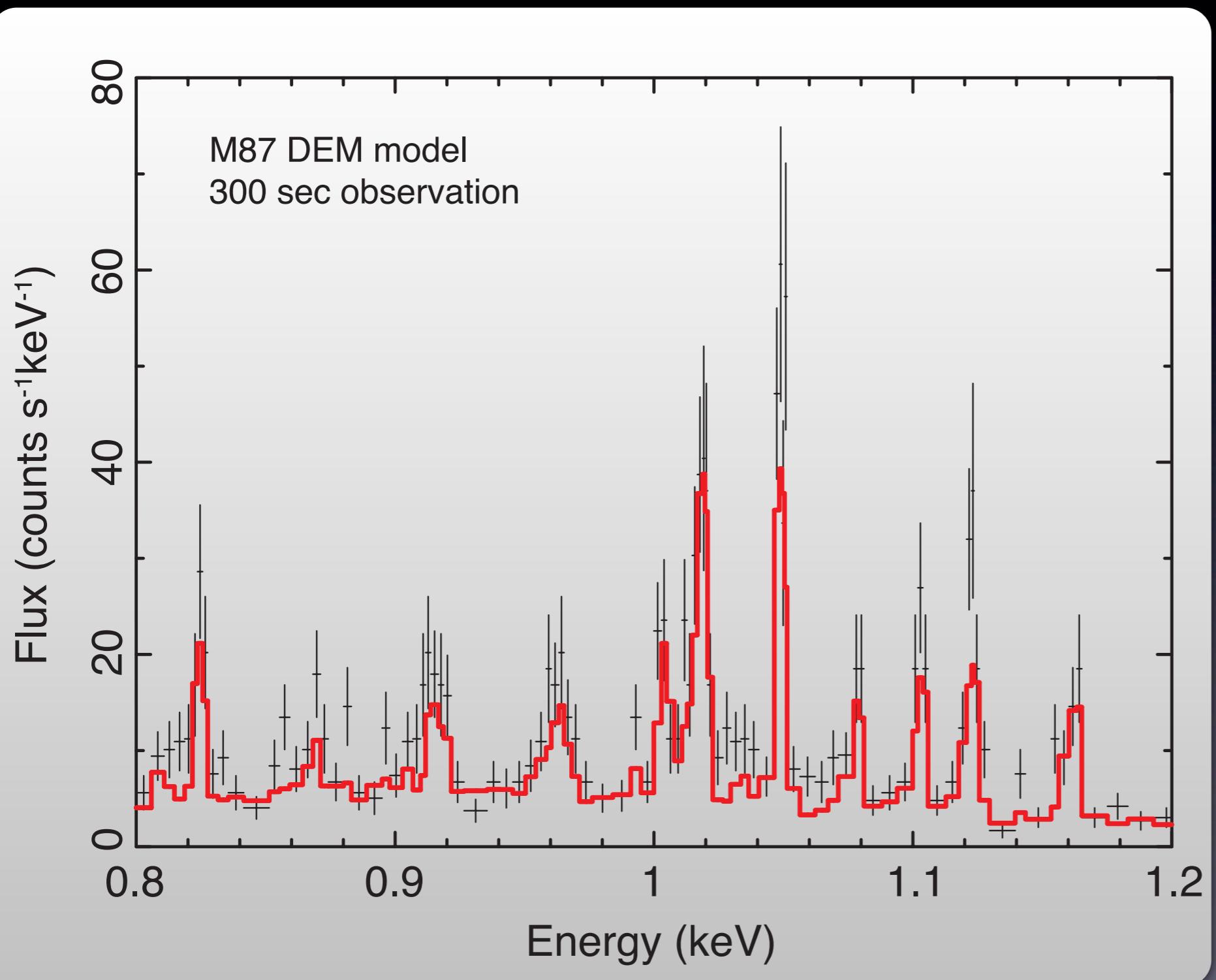
# Micro-X Obs of M87



Simionescu et al. 2008

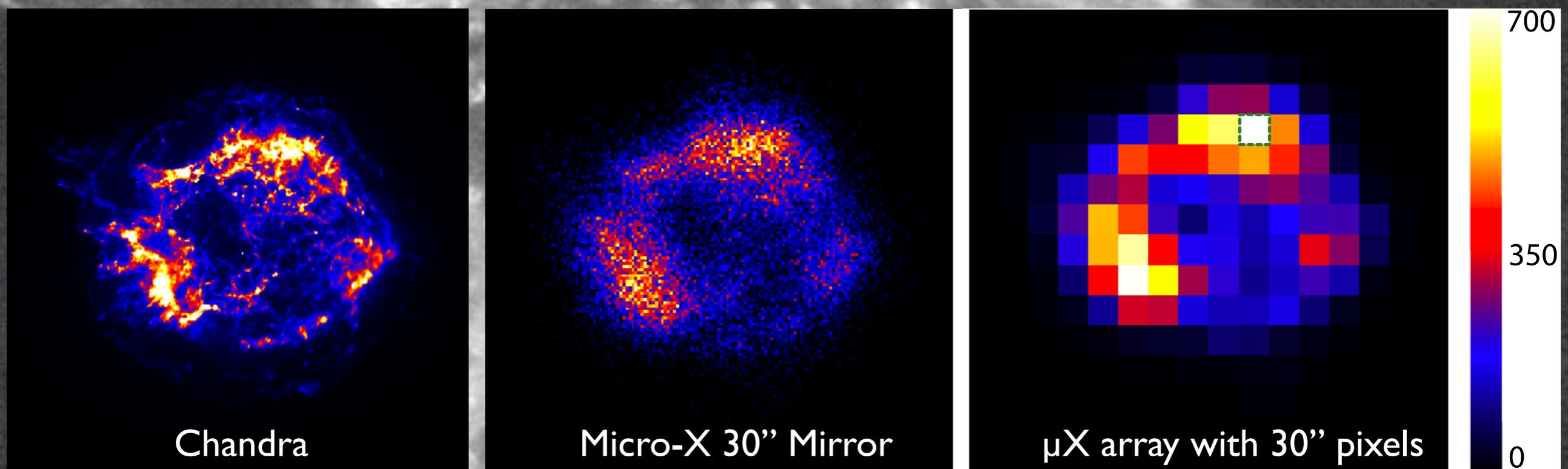


# Micro-X Obs of M87



- Place detailed constraints on the temperature distribution function.
- Reduce the systematic uncertainties in the abundances.
- Measure the degree of turbulence in the plasma.
- Investigate whether different temperature phases have distinct abundances and/or velocities, which would provide insight into the interaction and relationship between the different phases, as well as their origin.

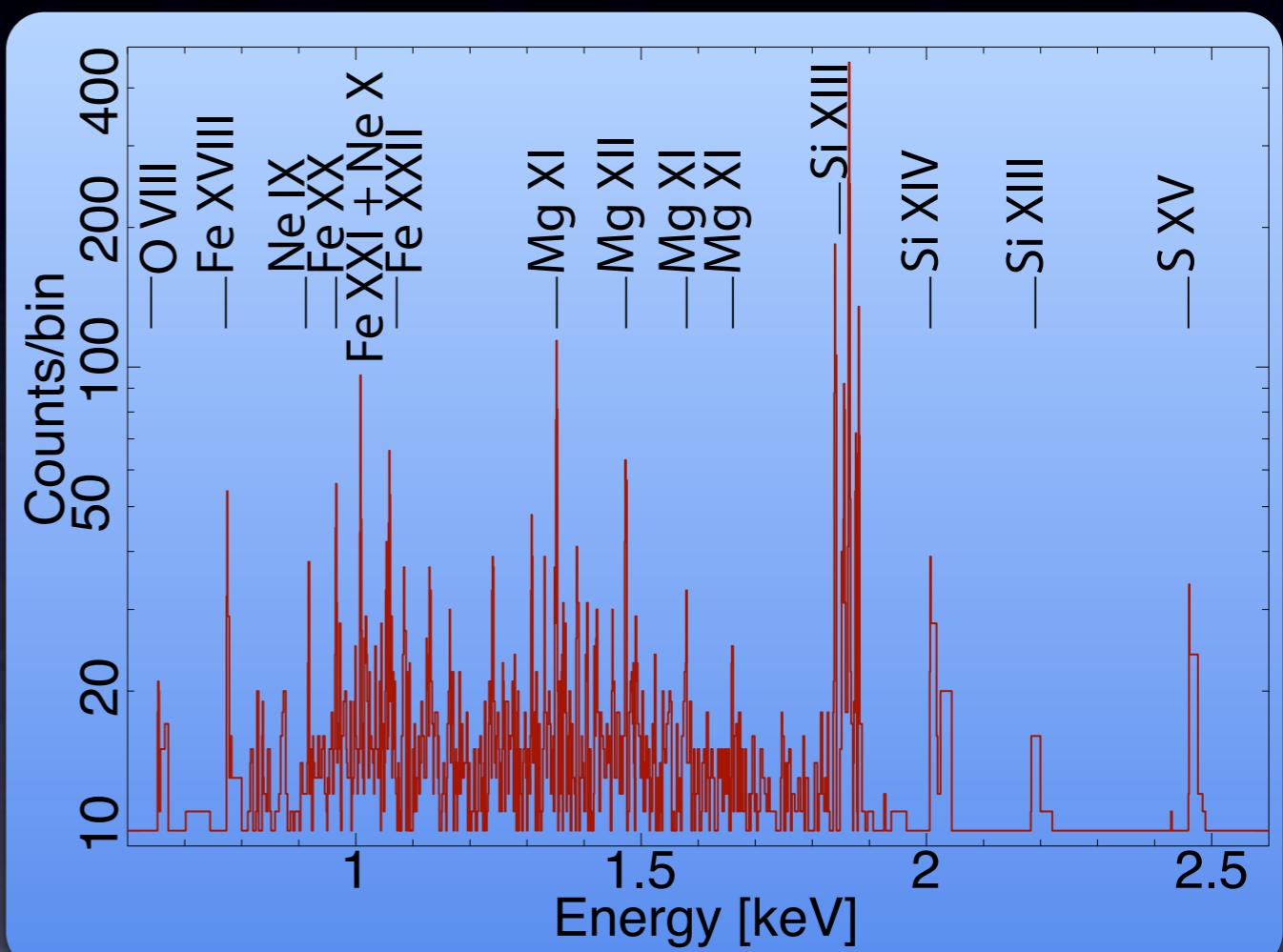
# Future Micro-X Target: Cassiopea A SNR



High-res mirror (MSFC)  
Larger 256-pixel array

# Cas A Science

- Perform line flux measurements and kT - estimates for the Fe-L emission.
- Provide a global oxygen measurement for Cas A.
- Measure discrete knot velocities and the “dynamic width” of the bright ring.





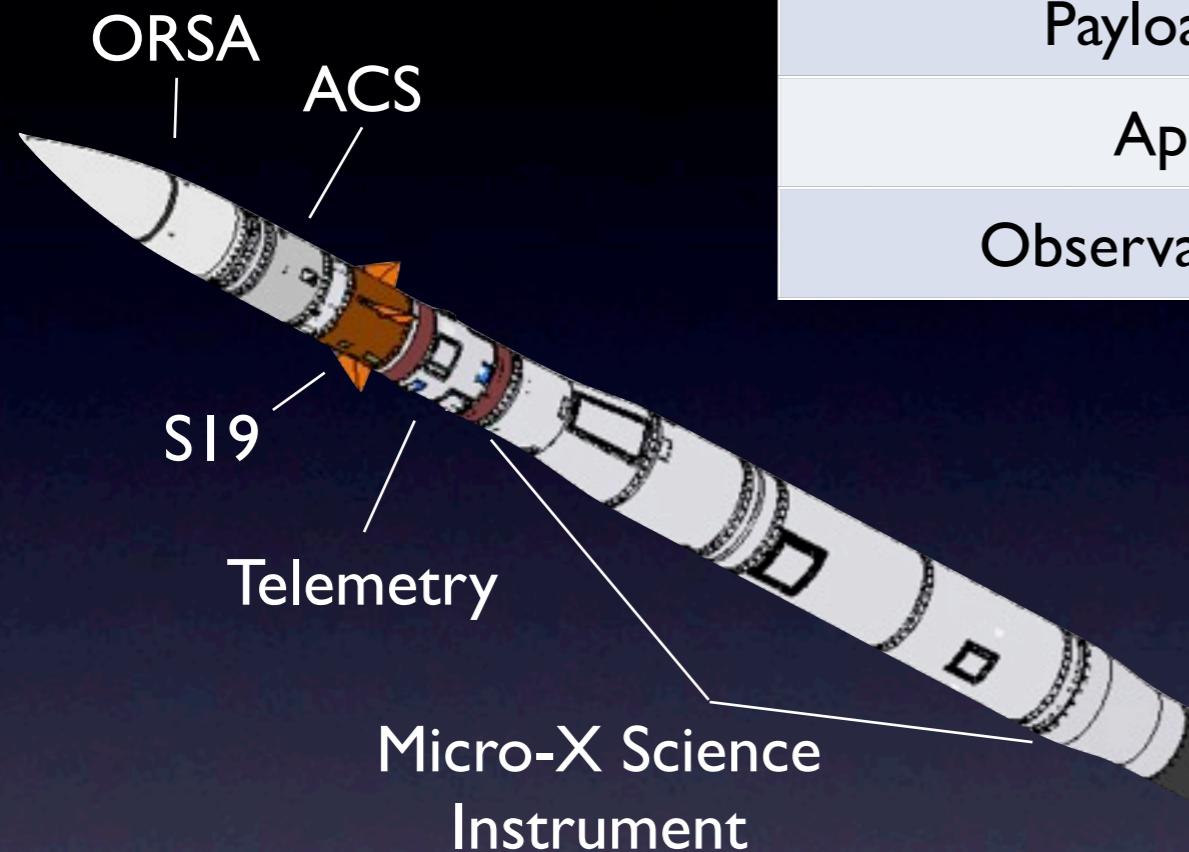
# Micro-X Specifications

## The Micro-X Instrument

Mechanical Characteristics	<ul style="list-style-type: none"><li>• Mass: 148 kg (231 kg with skin)</li><li>• Length: 3727 mm</li></ul>
Bandpass	0.2 – 3.0 keV
Field of View	11.8 arcmin
X-Ray Optics	<ul style="list-style-type: none"><li>• Conical approximated Wolter optics</li><li>• Collecting area <math>\sim 300 \text{ cm}^2</math> @ 1 keV</li><li>• Focal Length: 2100 mm</li><li>• 2.4' Point Spread Function</li></ul>
Microcalorimeter Array	<ul style="list-style-type: none"><li>• 128 pixels</li><li>• Pixel pitch: 600 <math>\mu\text{m}</math> = 0.98 arcmin/pixel</li><li>• 2 - 4 eV energy resolution @ 1 keV</li></ul>

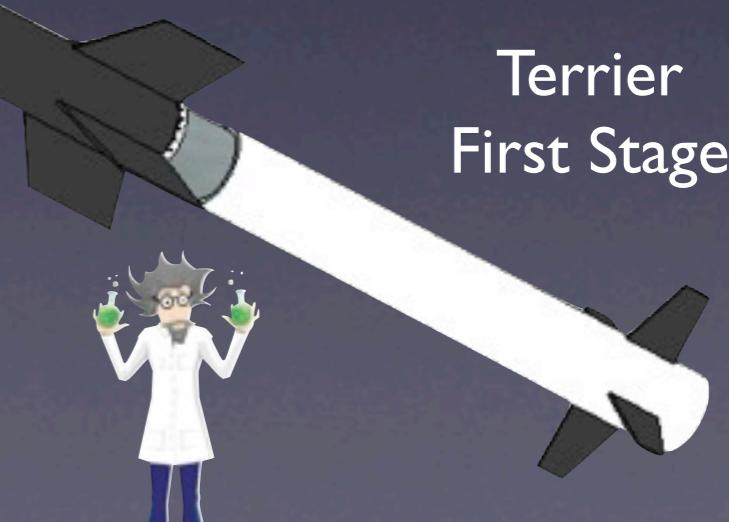
## Micro-X Specifications

Launch Vehicle	Terrier Black Brant MkI (Mod2)
Launch Site	White Sands Missile Range
Payload Mass	420 kg
Apogee	299 km
Observation Time	340 seconds above 150 km

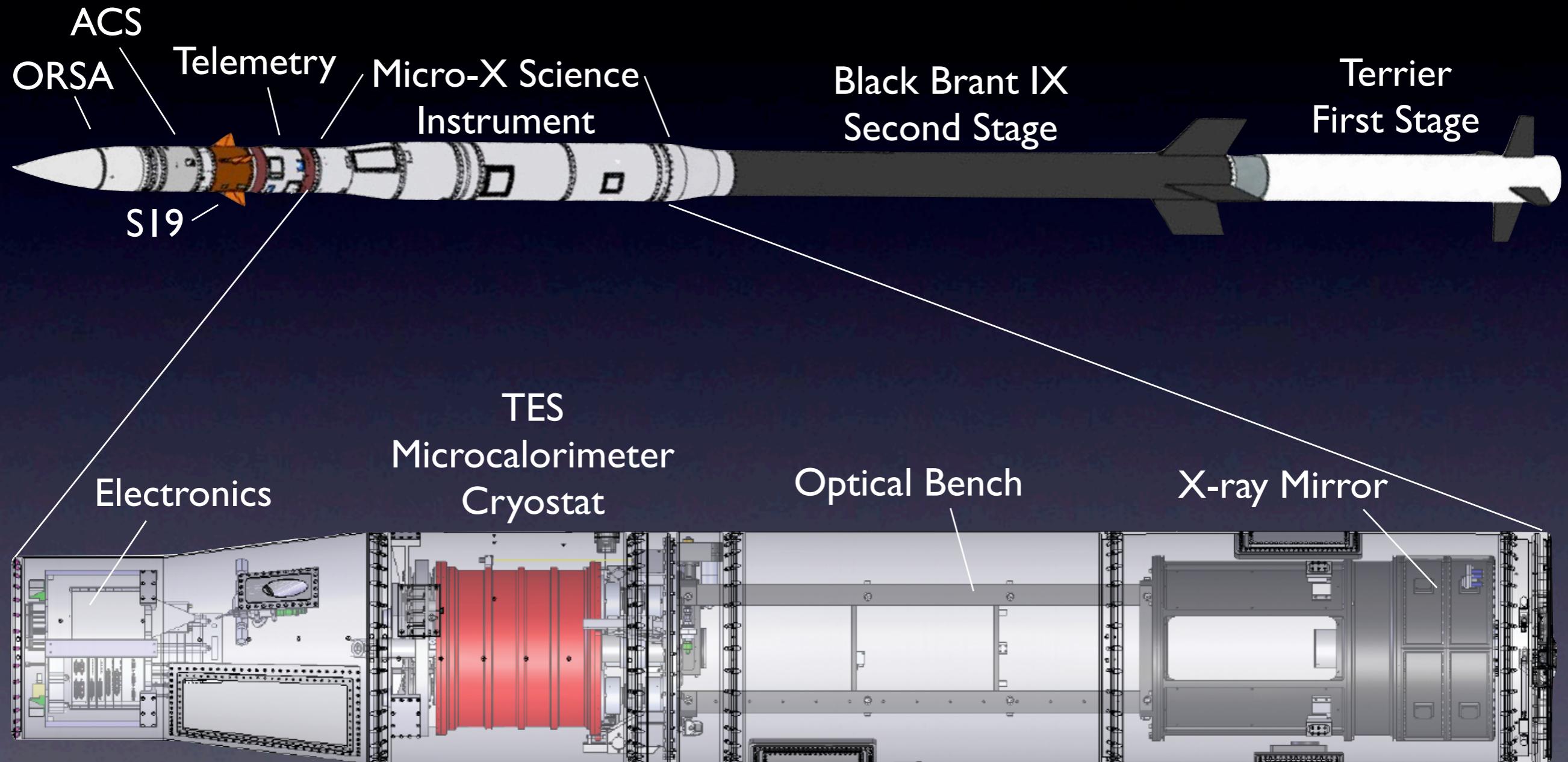


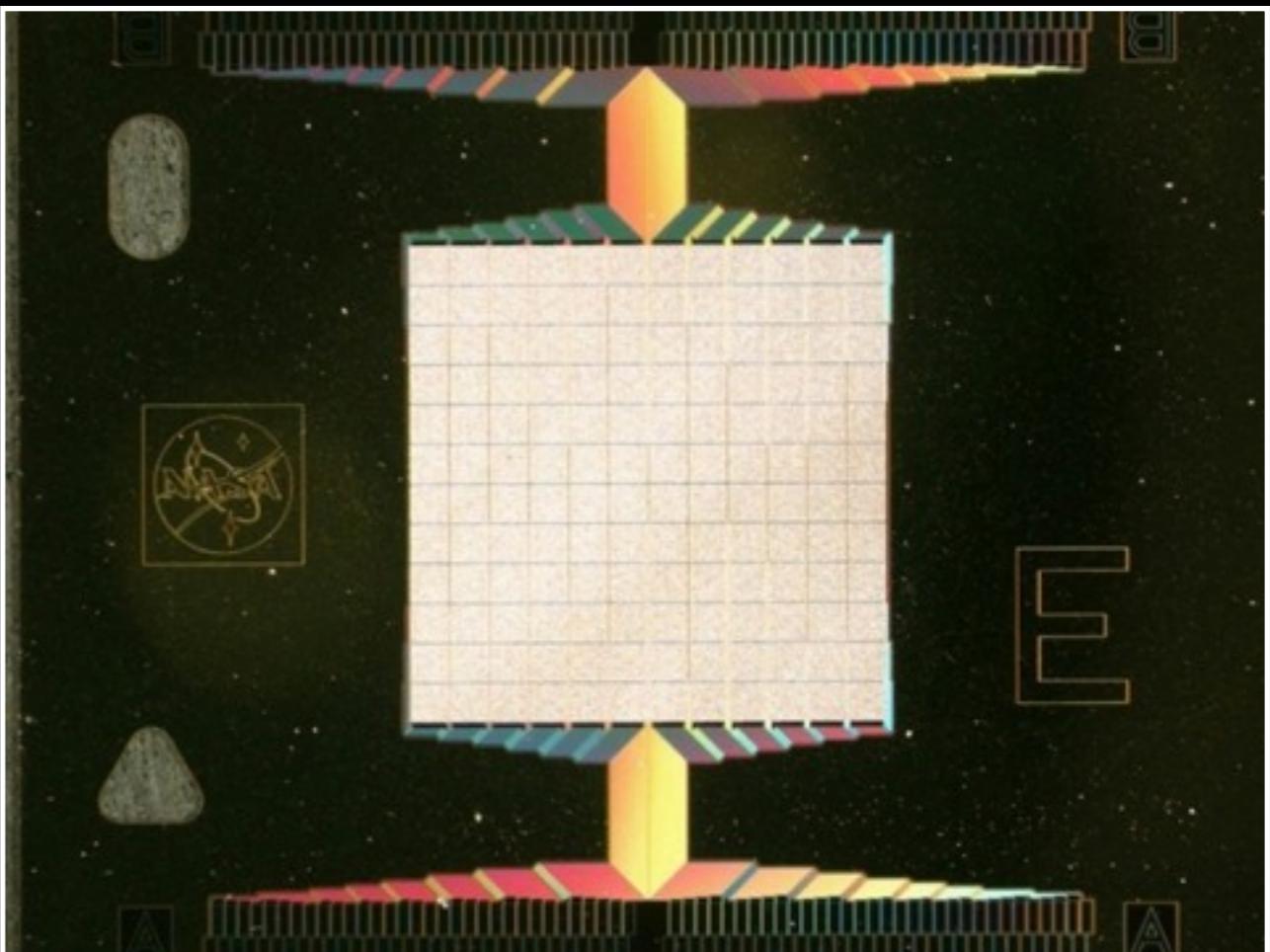
First Flight in  
2011

# The Micro-X Sounding Rocket

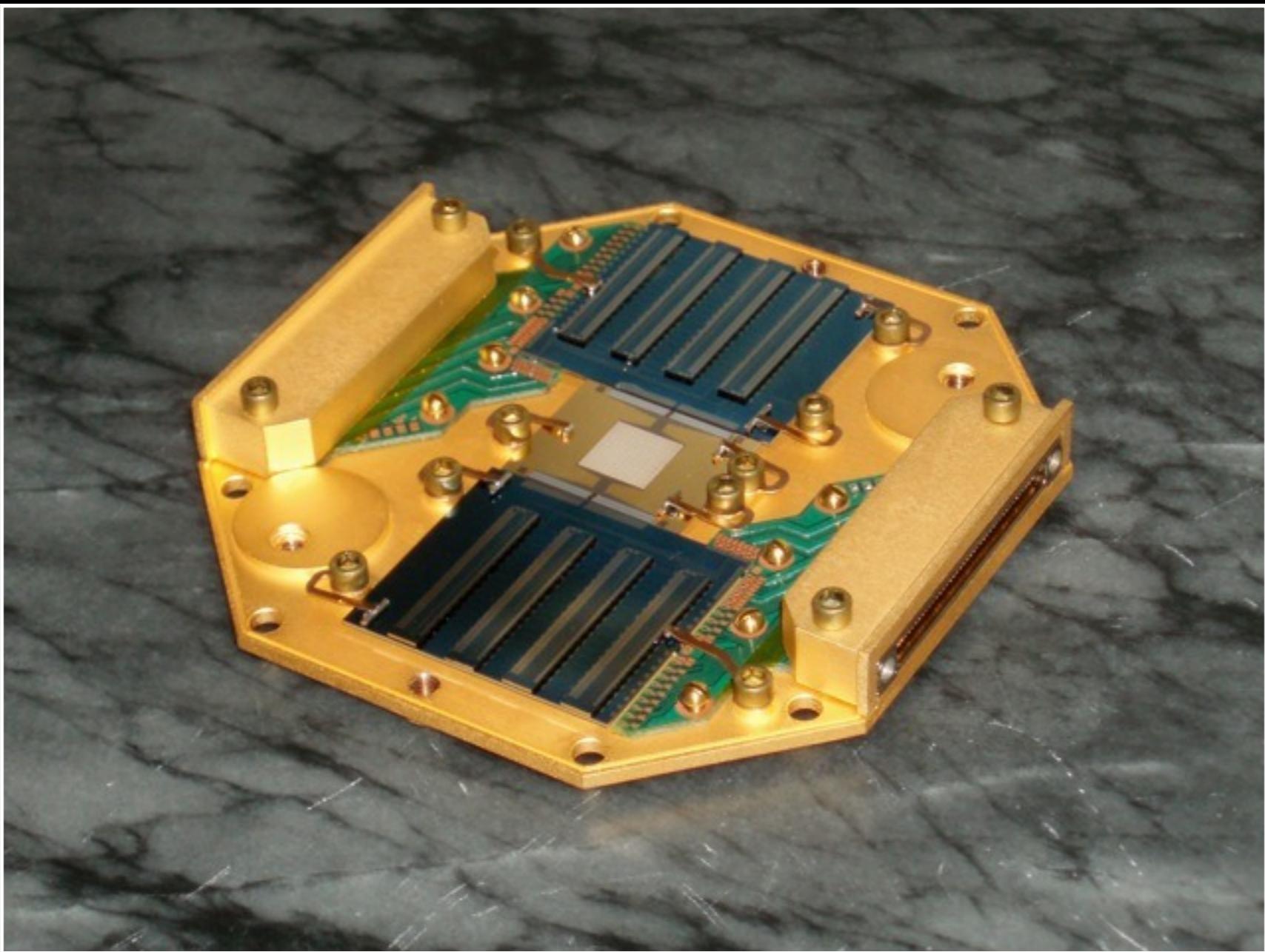


# The Micro-X Sounding Rocket

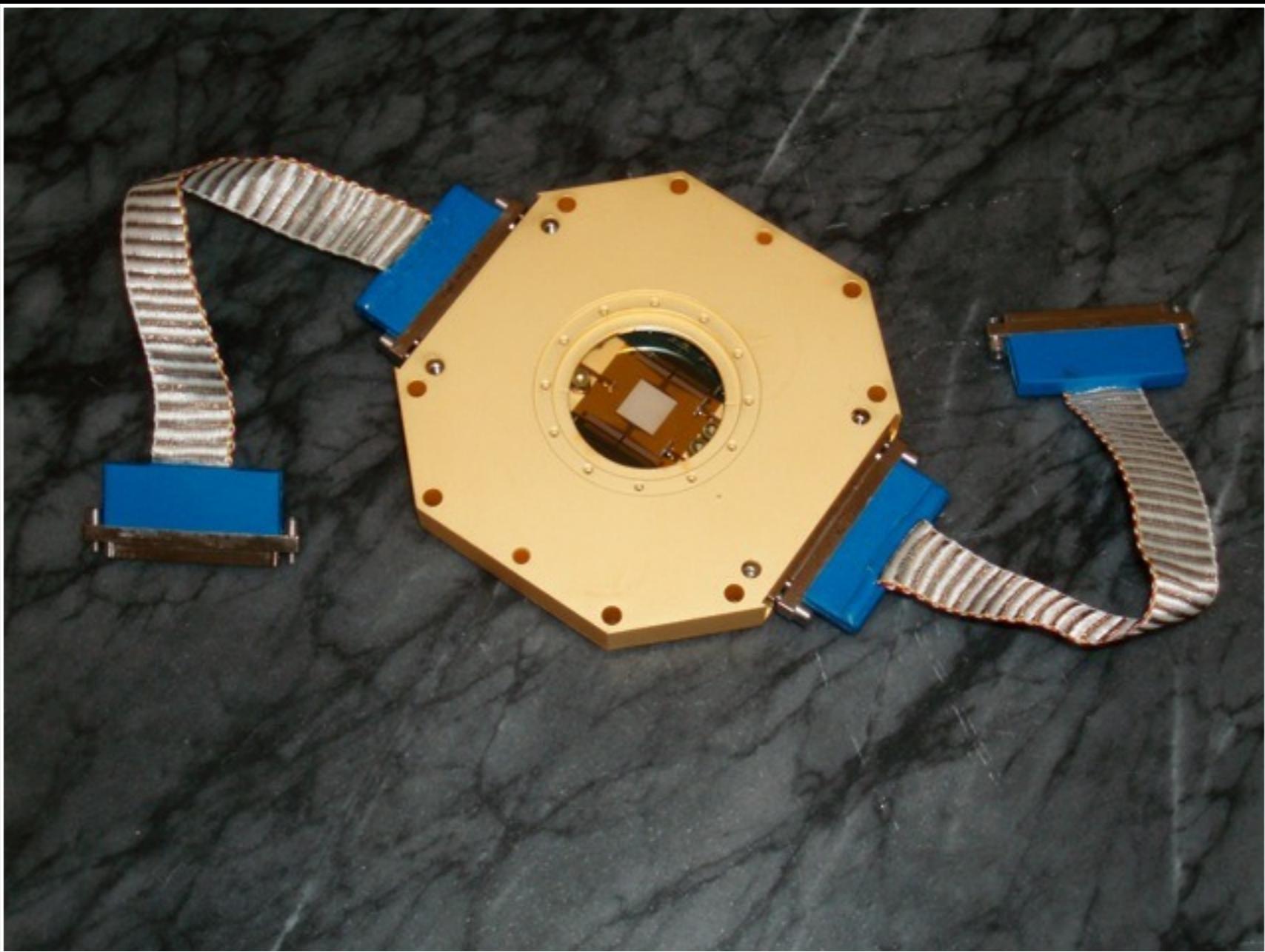




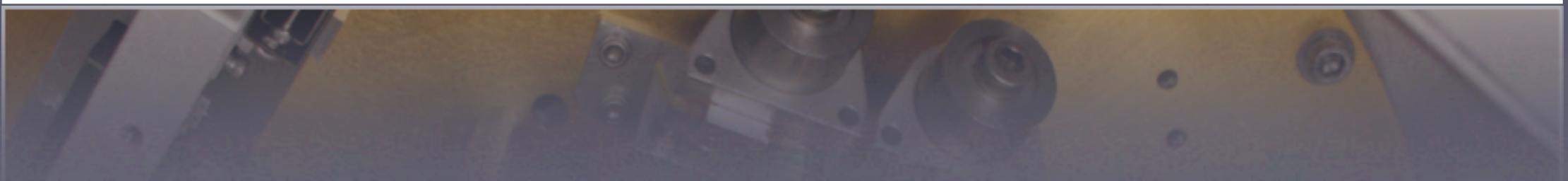
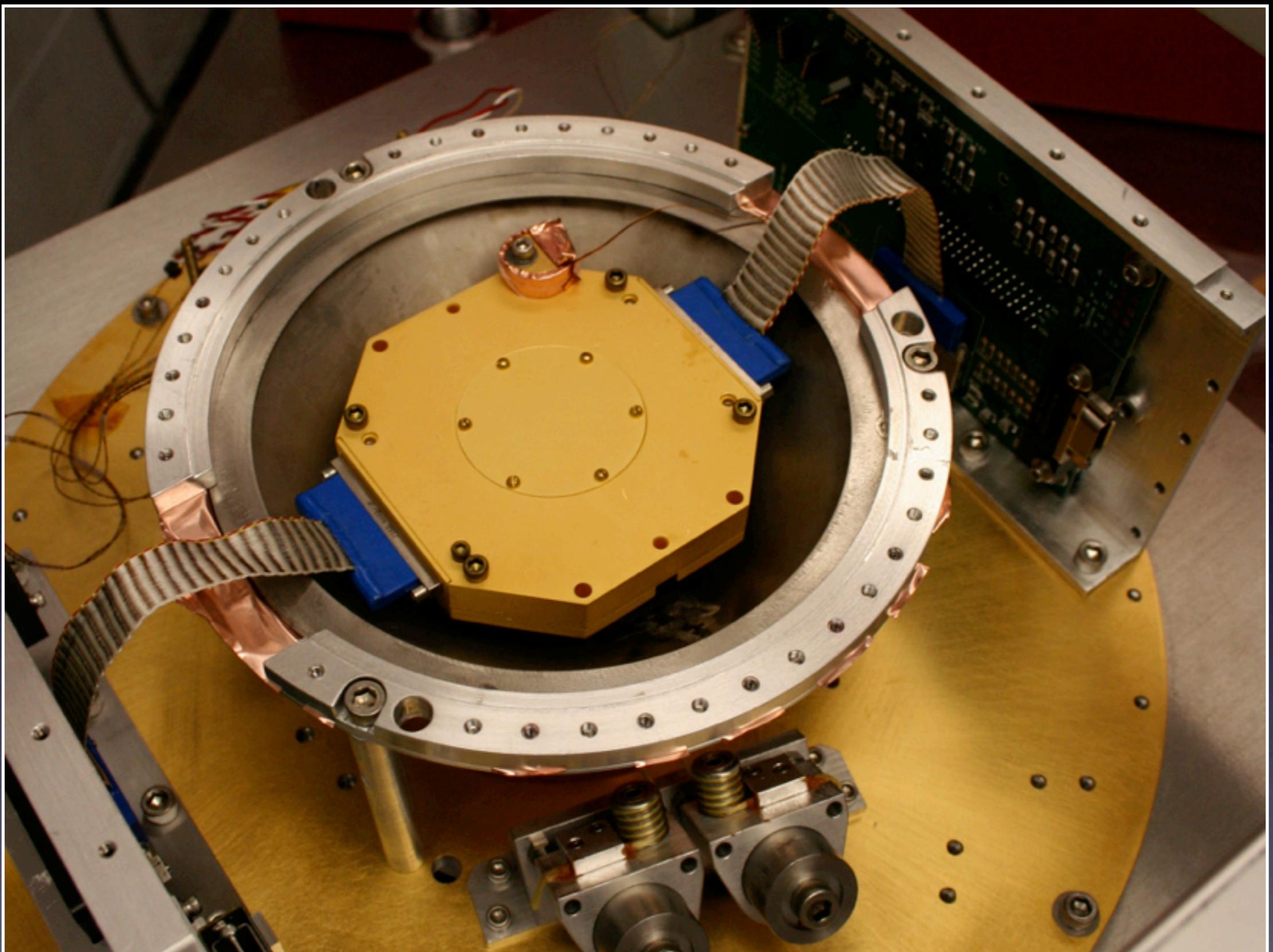
Micro-X Microcalorimeter Array  
 $12 \times 12 = 7.2\text{mm} / \text{side}$

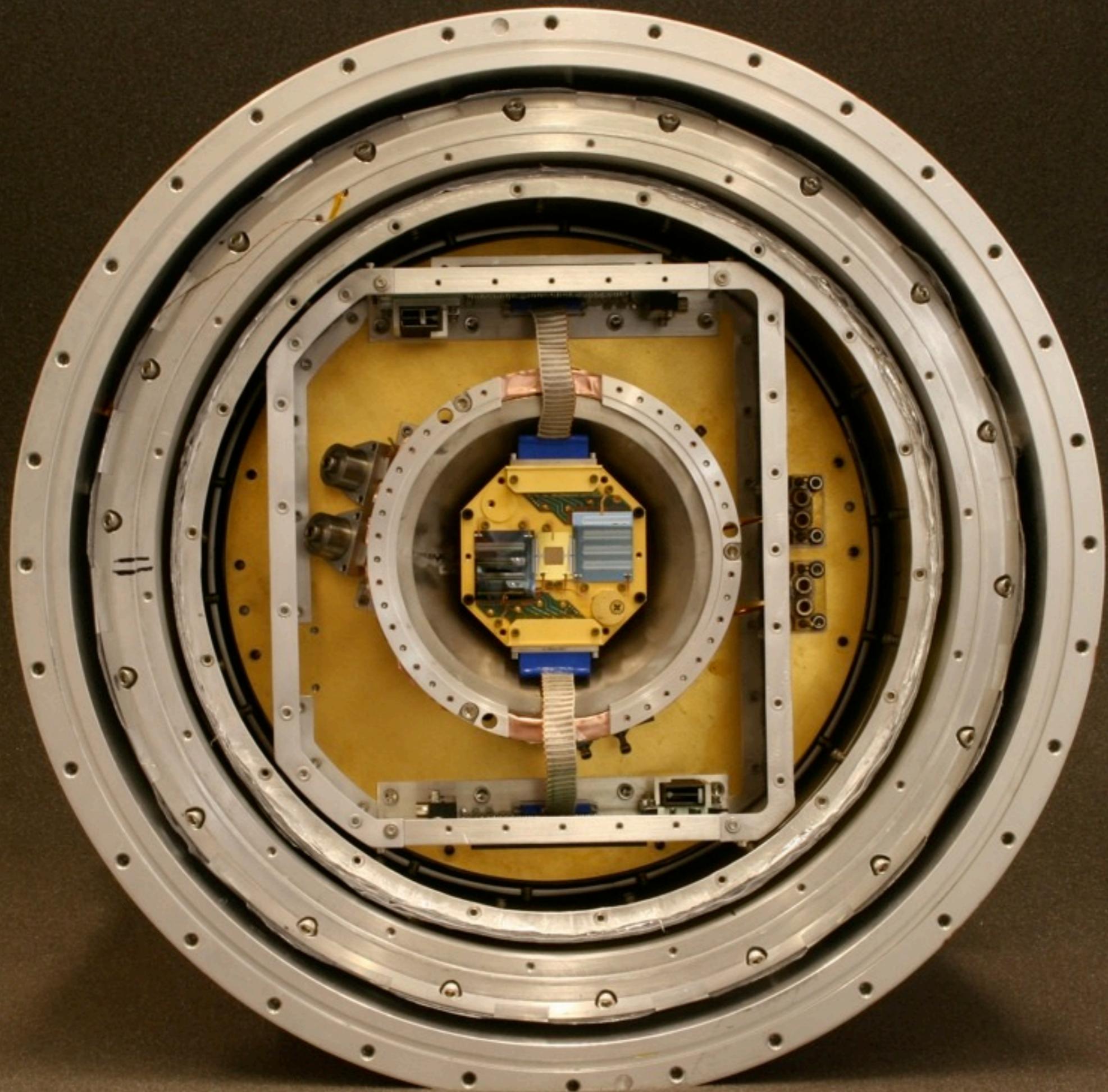


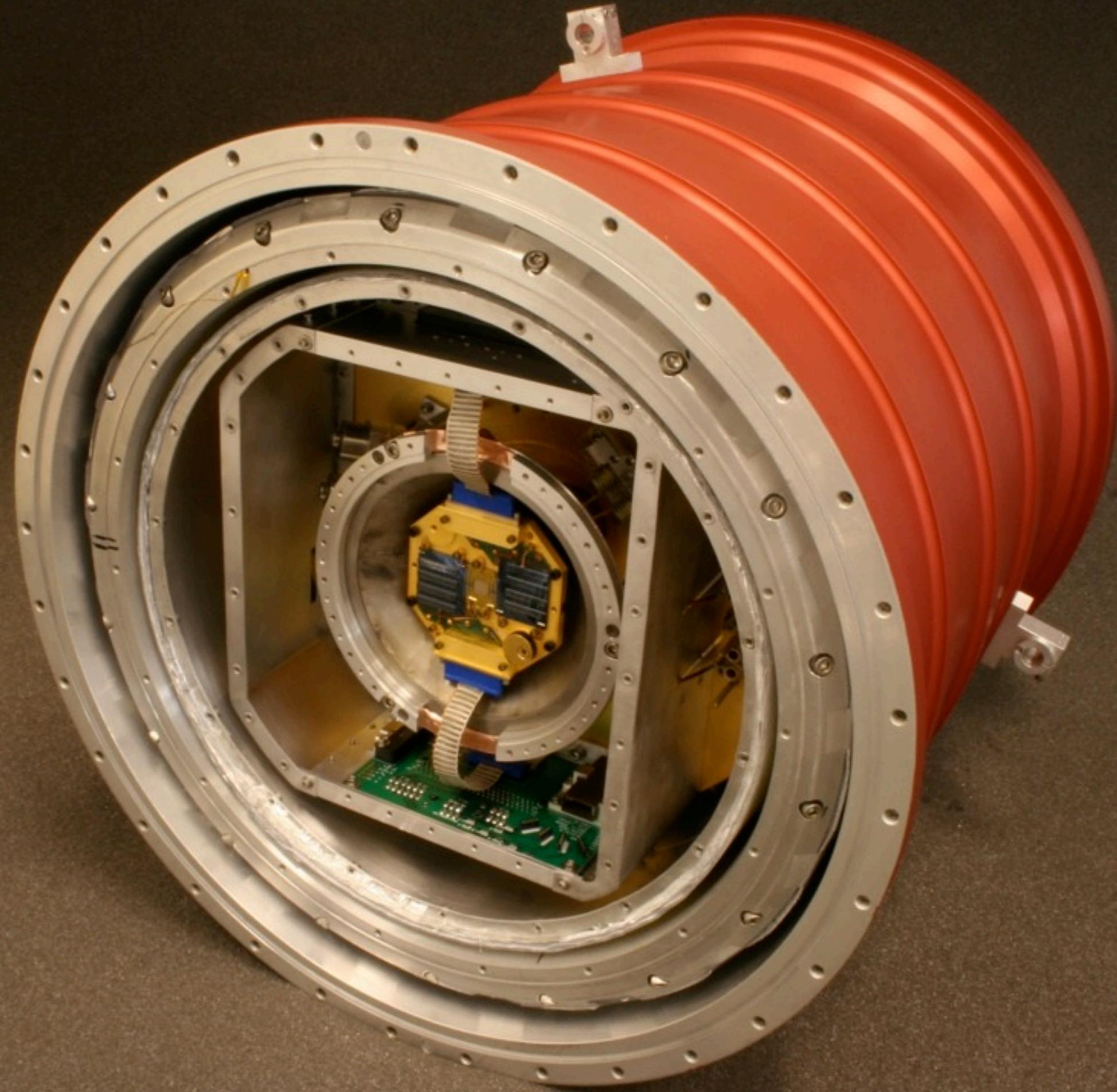
# Micro-X Focal Plane



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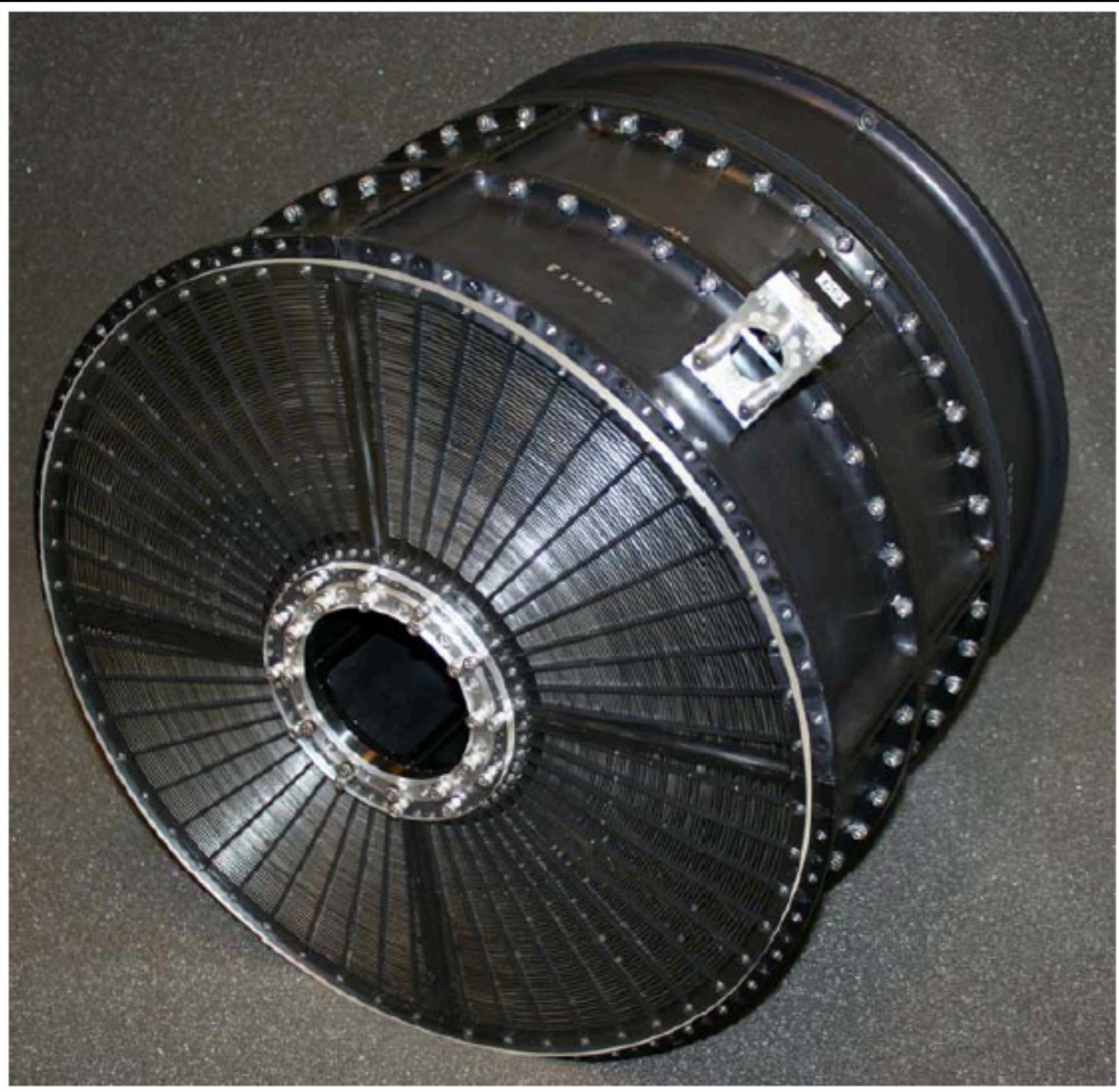






# The Micro-X Cryostat

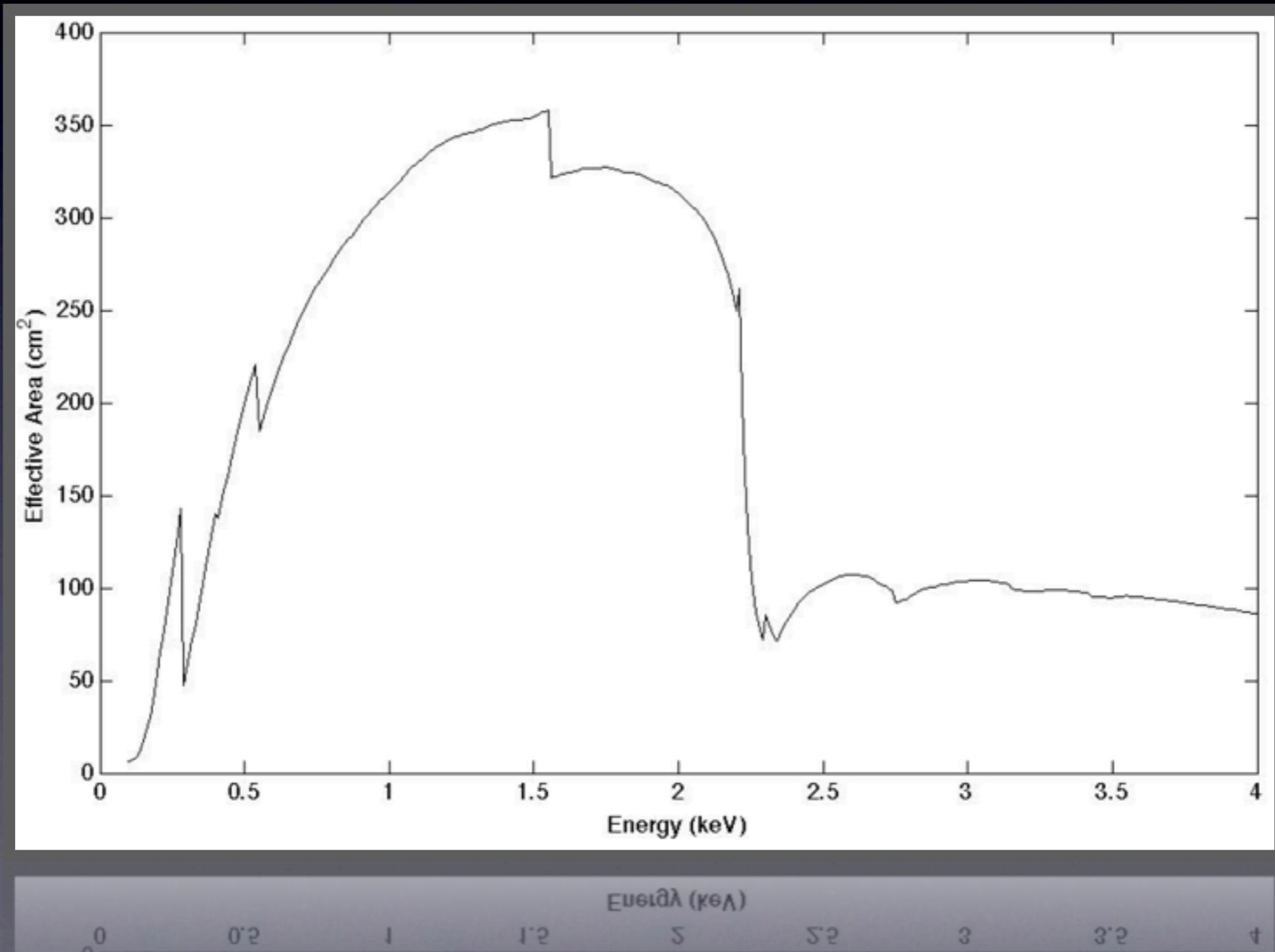
# Micro-X Mirror



- SXS Rocket Mirror Housing (1988)
- 2-stage Wolter I conically approx.
- 2.1m focal length, 70 shells  $\times$  4 quadrants
- Astro-E2 Spare gold-covered epoxy-replicated foils

# Micro-X Effective Area

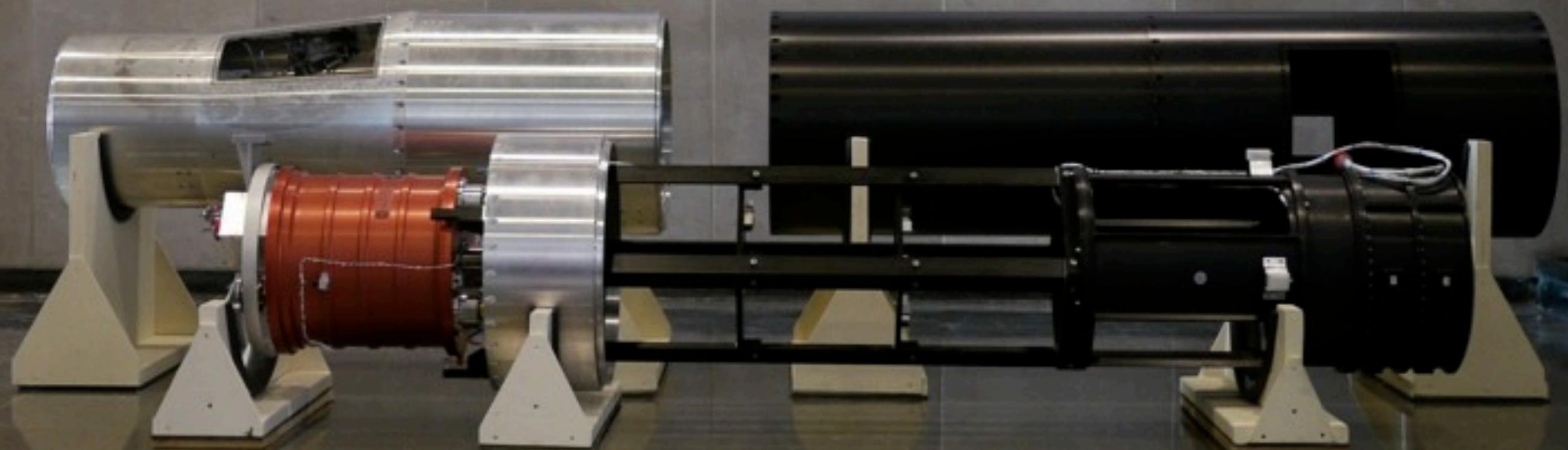
## (Mirror + Filters +Detector QE)

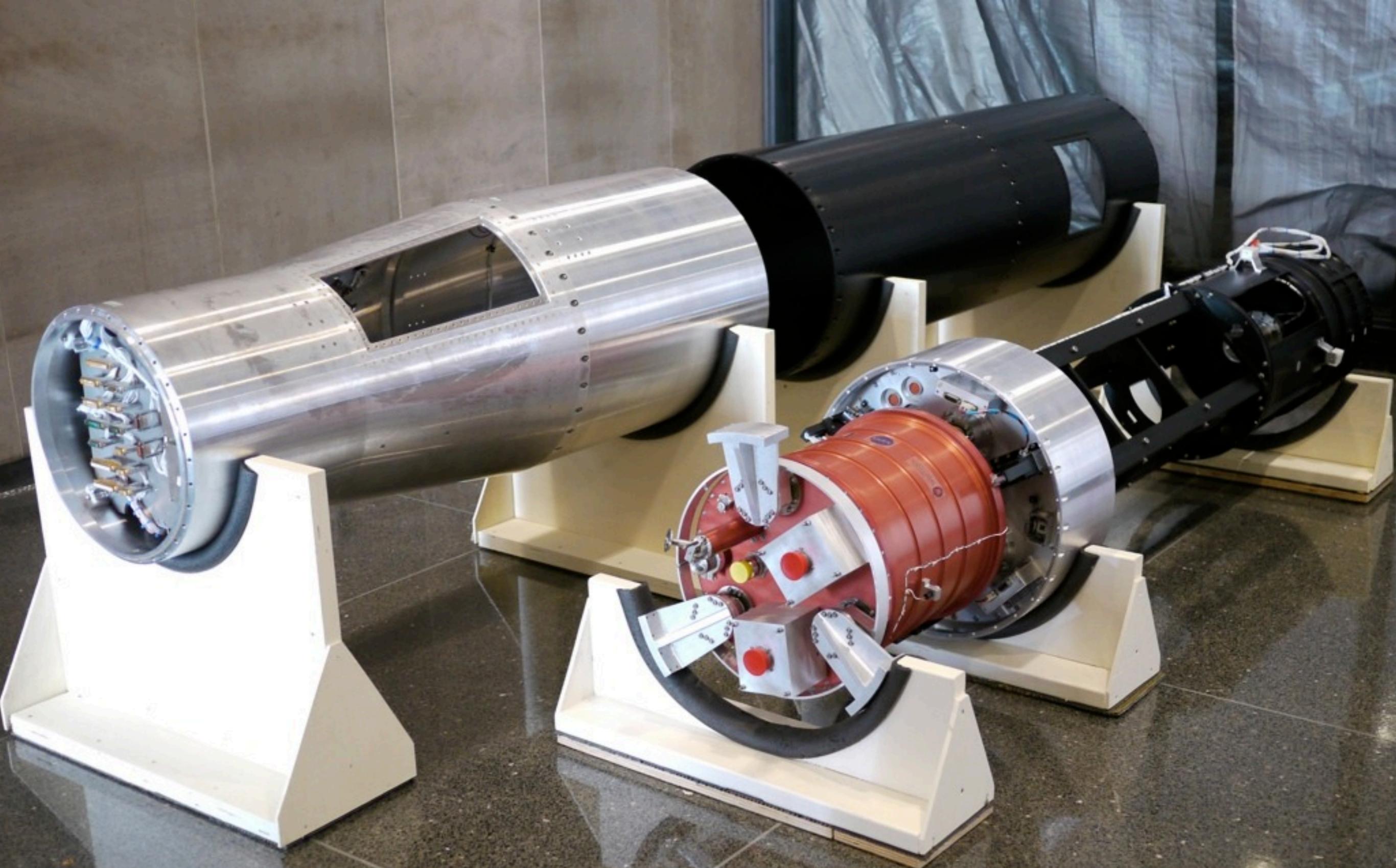


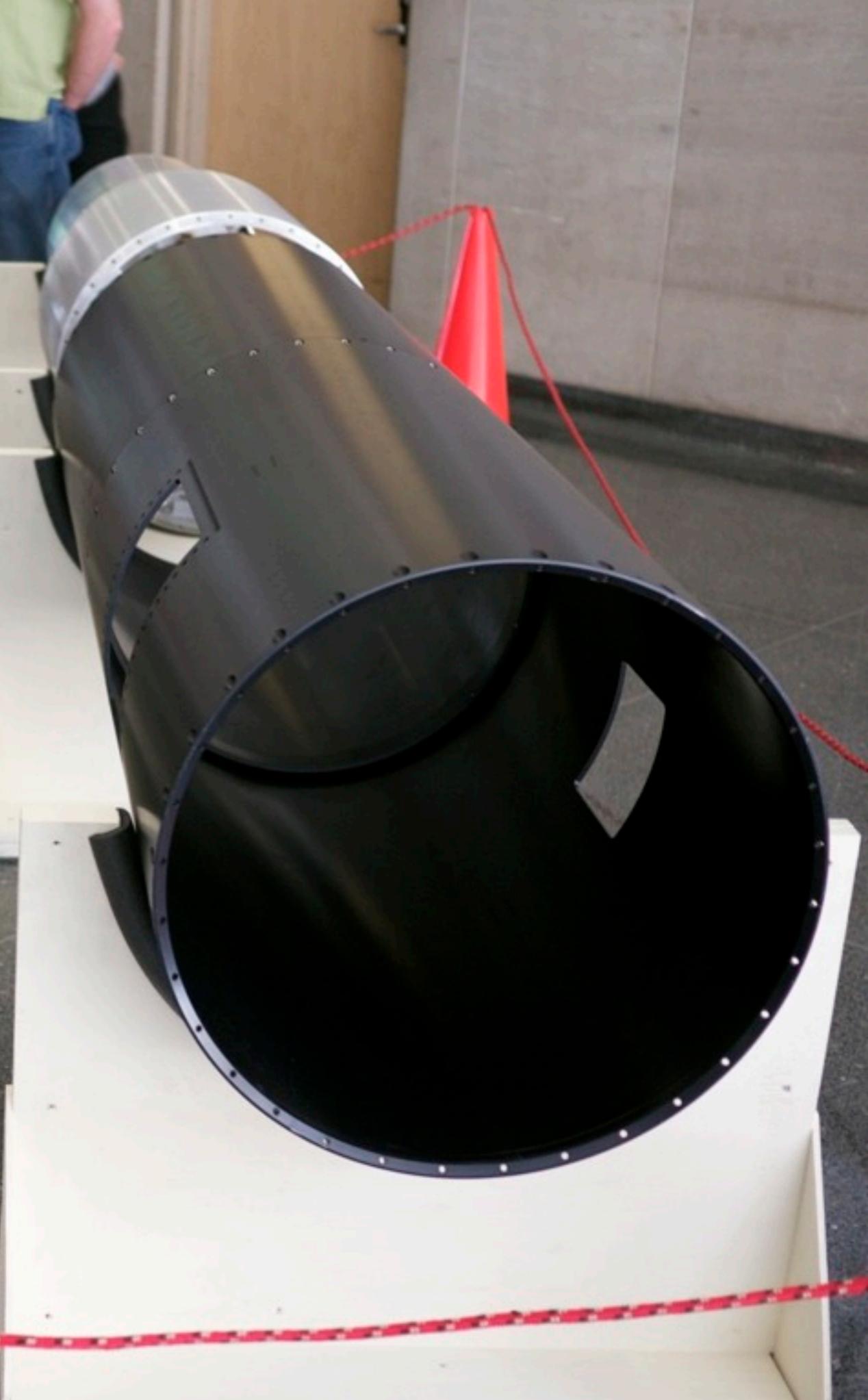
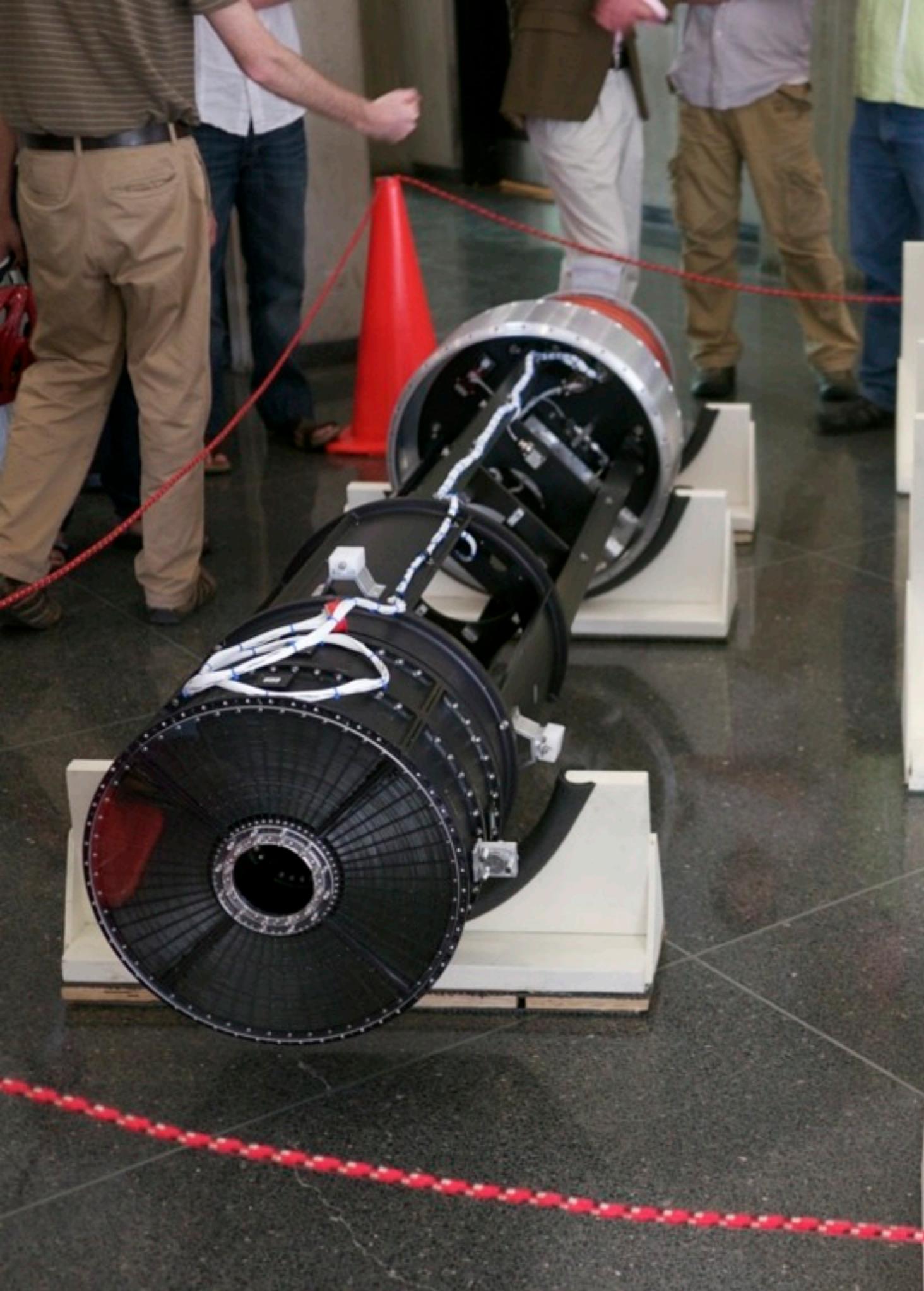


# MICRO-X

## High Resolution Microcalorimeter X-ray Imaging Rocket

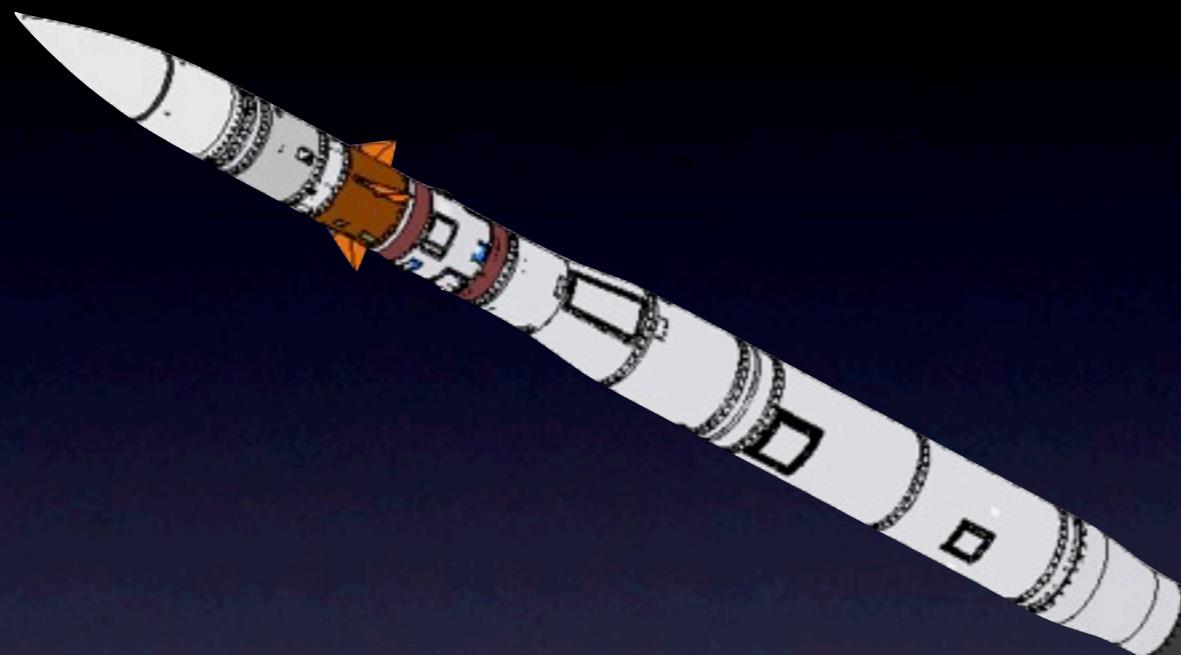








# Micro-X: 2011



Micro-X Spectrum in a 300 s Observation

